

REMARKS

The specification has been amended to reinstate the original paragraph bridging pages 12-13.

Claim 22 has been amended to address the §112 rejections. Claim 22 also has been amended to better define the claimed invention and distinguish the claimed invention from the prior art. More particularly, claim 22 has been amended to incorporate certain limitations of claim 23 and the limitations of claim 25 and the limitations of claim 33. Claims 24, 25, 33, 35 and 36 have been canceled.

The provisional obviousness-type double patenting rejection is noted. Applicants will file a Terminal Disclaimer, if necessary, upon indication of allowability of the claims.

The art rejections are respectfully traversed. Considering first the rejection of claims 22-28 and 31-39 as obvious from JP '180, on page 4 of the Action, the Examiner states: "The cited reference(s) disclose(s) the features including the claimed material and BCC structure (abstract) and process steps such as melting, heating/homogenizing, quenching in oil or iced water" (see Detailed Description [0013]. (underlining added for emphasis)

Applicants respectfully disagree with Examiner's view. JP '180 does not demonstrate use of quenching in iced water, i.e. as required by Applicants' claim 22, step (4).

Granted, in the Detailed Description [0013] of JP '180, the following description is noted:

"... keeping the aforementioned ingot for 1 to 5 hrs at the temperature of 1200 to 1400°C (provided that TiCr₂ mono-phase regions are excluded), followed by carrying out quenching processing in oil or iced water ..."

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However, in the working Example [0014], the following description is noted:

“... all the data in this example were collected for alloy samples obtained by (1) after casting, subjecting the as cast ingot to a heat treatment consisting of heating for 2 hrs at 1400°C, followed by water-cooling, to form the BCC structure and (2) thereafter pulverizing the resultant ingot in air, followed by the activation treatment comprising 4 cycles of evacuation at 10^{-4} torr + hydrogen pressurization at 50 atom at 60°C. ...”

(underlining added for emphasis).

In other words, there is no teaching of “use of iced water for cooling the hot ingot” in the working Example of JP ' 180.

Moreover, in [Table 2] ([0022] of JP '180), the prior art hydrogen storage alloy was obtained by the treatment, 1300°C×2hr-oil-cooling (lowest column in [Table 2]).

Thus, there is no actual teaching or suggestion within the four corners of JP '180 of the advantages of quenching in iced water. In fact, all of the actual examples in JP '180 point to quenching in fluids other than iced water.

In contrast, the present inventors have found that it is important and critical to rapidly cool a heated homogeneous alloy in iced water and that it is inappropriate to apply the heat-treated alloy to simple water-quenching and oil-quenching.

In order to demonstrate the criticality of iced water quenching and the advantages thereof, Applicants have conducted comparison experiments, as set forth in the enclosed 132 Declaration, which demonstrates:

Graph 1: which shows X-ray diffraction patterns of Ti-57.5Cr-2.5 Mo alloys (oil-quenched or iced water-quenched after heat treatment).

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From Graph 1, it is shown that the iced water-quenched alloy has only clear BCC peaks while an oil-quenched alloy is contaminated with C15 & C36 Laves.

Graph 2: which shows PTC curves of Ti-57.5Cr-2.5Mo alloys oil-quenched or iced water-quenched after heat treatment).

From Graph 2, it is shown that the iced water-quenched alloy provides higher protium concentration (mass%) values, about 3.4 to 3.5 mass%, than an oil-quenched alloy.

In [0018] on page 4, column 6, lines 6 to 16 of JP ' 180, the following is noted:

“Hydrogen absorption and desorption characteristics (PCT patterns) of the $Ti_{41}Cr_{56}W_3$ alloy samples which were obtained by arc-melting, and then keeping for 2 hrs at 1400°C, followed by the heat treatment of water-quenching in the same manner as aforementioned are shown in FIG. 4 which shows that the maximum hydrogen capacity of the resultant alloy is about 2.3 wt% at 40°C and about 2.4 wt% at 0°C which are good values, and the hydrogen-desorbing property thereof has significantly good flatness of the plateau portion at 40°C.”

Thus, the prior art suggestion “quenching in oil or iced water” (see Detailed Description [0013] of JP '180) completely fails to teach or suggest that the iced water-cooling is critical. The prior art “cooling in oil” is not the same as rapid cooling in iced water.

In contrast, the present inventors have discovered that “rapidly cooled preferably at a cooling rate of more than 100K/sec.” (page 19, lines 31 to 32 of the Applicants' sworn specification) is critical.

The hydrogen storage alloys of the present invention have unexpectedly higher hydrogen storage capacities (see FIGS. 9 and 10). In FIGS. 9 and 10 of the subject Application, each storage capacity of the instant alloys is over 2.6 mass% within a range of both $0 < Mo \text{ at\%} < 5$ and $0 < W \text{ at\%} < 5$.

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As noted in the enclosed 132 Declaration, the difference of 0.1 to 0.2 mass% per unit alloy mass is a remarkable value in this field in connection with Ti-Cr-system alloys having a quite low level of Mo and/or W. The increase of even 0.1 to 0.2 mass % in the hydrogen storage capacity is an unexpected, superior effect over the prior art alloys.

This difference is derived from the difference between prior art alloy treatment processes and the instant unique ones, and reflects the greatly different lattice structures (i.e., highly BCC-rich structures).

In [0016] on page 4, column 5, lines 2 to 13 of JP '180, the following is noted:

"FIG. 2 shows hydrogen absorption and desorption characteristics of the aforementioned example samples (1) to (5) at 0°C. In this FIG., (1) $\text{Ti}_{27}\text{Cr}_{56}\text{Mo}_7$ and (2) $\text{Ti}_{30}\text{Cr}_{63}\text{Mo}_7$ alloys have merely a slight hydrogen storage capacity and scarcely desorb hydrogen. The hydrogen storage capacity is improved for (3) $\text{Ti}_{33}\text{Cr}_{60}\text{Mo}_7$ and (4) $\text{Ti}_{36}\text{Cr}_{57}\text{Mo}_7$ alloys, and the plateau equilibrium pressure value reaches to near 1 MPa for (3) $\text{Ti}_{33}\text{Cr}_{60}\text{Mo}_7$, and is 1 MPa or less for (4) $\text{Ti}_{36}\text{Cr}_{57}\text{Mo}_7$ which gives a maximum hydrogen absorption and desorption value and a good value for flatness of the plateau portion. For (5) $\text{Ti}_{39}\text{Cr}_{54}\text{Mo}_7$, the hydrogen storage capacity is slight and the alloy has a tendency to scarcely desorb hydrogen. The hydrogen absorption and desorption characteristics of the aforementioned (5) $\text{Ti}_{39}\text{Cr}_{54}\text{Mo}_7$ at 0°C and 400°C are shown in FIG. 3."

From the phrase "the plateau equilibrium pressure value ... is 1 MPa or less for (5) $\text{Ti}_{36}\text{Cr}_{57}\text{Mo}_7$ which gives a maximum hydrogen absorption and desorption value ..." (underlining added for emphasis) of JP '180, it is apparent that the minimized Mo level based on the teaching of JP '180 is 7 at% as a minimal limit. Similarly the prior art JP '180 technique gives not less than 3 % at a W level.

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In contrast, the present inventors have succeeded in reducing a Mo and W level greatly (i.e., $0 < \text{Mo at\%} < 5$ and $0 < \text{W at\%} < 5$) while increasing the hydrogen storage capacity to more than 2.6 wt%.

This success is based not only on the unique processes but also the formation of unexpected BCC-rich structure (even at an extremely low Mo and W levels) achieved by the instant claimed production processes (see for example FIG. 12 wherein the as-cast alloy lacks a BCC peak in the prior art while the as-homo alloy have clear BCC peaks according to the present invention).

In [0009] on page 3, column 3, lines 7 to 19 of JP '180, the disclosure notes:

“From the knowledge acquired by the inventors of the present invention and co-workers so far, the hydrogen absorption and desorption characteristics can be remarkably improved among the BCC alloys particularly in those BCC alloys in which the phase is regularly decomposed into two very fine phases of a nano-order due to the spinodal decomposition. ... [t]he two phases that are formed due to the spinodal decomposition, grow in specific crystal orientations and have mutually different lattice constants would finally have a periodical structure with a spacing of 1.0 to 100 nm.”

JP '180 also states “the phase separation will be sufficiently derived, and alloys having excellent hydrogen absorption and desorption characteristics will be obtained under two-phase states” ([0011] on page 3, column 3, lines 40 to 42 of JP '180).

In addition, JP '180 states: “optimizing the crystal structure strain under the two-phase separation state in the alloys heat-treated” ([0011] on page 3, column 3, lines 46 to 47 of JP '180).

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From the above disclosures, it is apparent that JP '180 fails to teach or suggest a "homogenizing" treatment as required by step (2) of claim 22 of the present invention. The prior art technical concept with faults leads to "The preferred range of Mo and/or W is 5% or more but 20% or less" ([0012] on page 3, column 4, lines 8 to 10 of JP '180).

In contrast, the present inventors have found that it is extremely important to:

- (1) repeatedly melt and solidify the starting mixture to form a heated homogeneous alloy,
- (2) maintain the resultant heated homogeneous alloy at a temperature within a range just below the melting point of the alloy (i.e., 1400°C or higher) for a predetermined time (rather a shorter period) of from 1 to 100 min, and
- (3) rapidly cooling the alloy from the above step (b) in iced water, and the combination of the above steps results in the formation of unexpected BCC-rich (or high hydrogen storage capacity) alloys even at a quite low level of Mo and W.

This is clearly pointed out by the present inventors, i.e., "such repeated melting and solidifying treatments ... to prevent the occurrence of a spinodal decomposing composition as much as possible" (page 9, lines 32 to 37 of the sworn specification) and "... apt to induce a spinodal decomposition readily, it is defined ... because spinodal decomposing tissues cause deterioration of alloy's hydrogen absorption and desorption characteristics." (page 19, line 33 to page 20, line 2 of the sworn specification).

Based on the prior art techniques, however, it is impossible to reach BCC-rich Ti-Cr alloys within $0 < \text{Mo at\%} < 5$ and $0 < \text{W at\%} < 5$, which have excellent hydrogen absorbing and

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desorbing properties, e.g., a hydrogen storage capacity of 2.6 mass % or more (see FIGS. 9 and 10; these values are incredible in the prior art).

In the present invention, "each individual metal thus weighed was thrown into an arc melting plant, subjected to repeated treatments (melting-stirring $\leftarrow \rightarrow$ solidification) for predetermined times (i.e., plural times, usually approximately 4 to 5 times)" (page 17, lines 29 to 36 of Applicants' sworn specification), and claims 23 and 36. JP '180 is completely silent about such repeated treatments.

Based on the prior art concept "... the hydrogen absorption and desorption characteristics can be remarkably improved among the BCC alloys particularly in those BCC alloys in which the phase is regularly decomposed into two very fine phases of a nano-order due to the spinodal decomposition. ... the two phases that are formed due to the spinodal decomposition, grow in specific crystal orientations and have mutually different lattice constants would finally have a periodical structure with a spacing of 1.0 to 100 nm." and "... the phase separation will be sufficiently derived, and alloys having excellent hydrogen absorption and desorption characteristics will be obtained under two-phase states", it is absolutely impossible to derive from such prior art teachings the formation of heated homogeneous alloys, as required by the instant claimed invention. JP '180 nowhere teaches or suggests that plural repeated (melting-stirring $\leftarrow \rightarrow$ solidification) treatments are important for obtaining remarkably higher hydrogen storage capacity alloys at a quite low level Mo and W, i.e. as required by claim 22, step (3).

In the JP '180 reference, the following should be noted:

In the Examples, the phrases "... keeping the aforementioned ingot ... at the temperature of 1200 to 1400°C" ([0013] on page 3, column 4, lines 15 to 17 of JP '180) and "... heated at

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1400°C for 2 hr" (in Example, [0014] on page 3, column 4, line 35 of JP '180) are present; however, it should be noted that the phrase "1300°C×2 hr-oil cooling" is disclosed in connection with the alloy having the composition giving a maximum value (Table 2 on page 4, lower paragraph of JP '180).

These passages suggest that the 1400°C or higher heat-treatment (i.e., treatment at a temperature within a range just below the melting point of the alloy) was not actually conducted.

It is considered that this is derived from the prior art idea "the spinodal decomposition is raised to form a two-phase separation state" while the "homogenizing" leads to an increase of BCC phases according to the inventor's idea.

It is noted that the prior art technique fails to recognize the importance of repeated melting and solidifying as specified in claim 22, step (2).

The present inventors have found that the highly elevated temperature is effective in forming BCC-rich alloys and the heat treatment has to carry out within a very short period of time.

In the working Examples of Applicants' sworn specification, all the alloys are produced at 1400°C or higher.

As demonstrated in the attached 132 Declaration, a short time heat treatment is preferable. See:

Graph 3: which shows hydrogen absorption and desorption characteristics of Ti-57.5 Cr-2.5 Mo alloy where the heat-treatment time varies at 1400°C; and

Graph 4: which shows PTC curve profiles of Ti-57.5 Cr-2.5 Mo alloy where the heat-treatment time varies at 1400°C.

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From Graphs 3 and 4 it is demonstrated that the prolonged heat-treatment deteriorates the hydrogen absorption and desorption characteristics of hydrogen storage alloy products.

From FIGS. 5, 9 and 10 of the subject Application, it is seen that the instant hydrogen storage alloys have a hydrogen storage capacity of 2.6 mass % or more. The prior art documents do not disclose such high hydrogen storage capacity values. Applicants have achieved excellent hydrogen storage metal alloys with hydrogen storage capacity of 2.6 mass % or more, accompanied with experimental data. Applicants submit that these unexpectedly superior hydrogen storage capacities reflect the novel fine crystal structure in the instant alloys.

See also Cr-Mo-Ti state diagrams, Graph 5.

In view of the foregoing amendments and comments and the enclosed 132 showing, it is submitted that the rejection of claim 22 and the several claims directly or indirectly dependent thereon as obvious from JP '180 is in error.

Turning to the rejection of claims 29 and 30, claim 29 is directly dependent on claim 22, and claim 30 is dependent on claim 29. The deficiencies of JP '180 vis-à-vis claim 22 are discussed above. JP '859 does not supply the missing teachings to JP '180 to achieve or render obvious claim 22 or any of the claims that depend thereon. The Examiner cites JP '859 as teaching conventional Ti-Cr-V alloys in the same field of endeavor or the analogous metallurgical art. More particularly, on page 6, item 16 in the Official Action, the Examiner states that "JP 10-121180 discloses Ti-Cr-V alloy is known. V is expensive and V could be replaced by Mo and/or W. However, JP 11-106859 in their abstracts disclose the conventional Ti-Cr-V alloys in the same field of endeavor or the analogous metallurgical art. ... The use of conventional materials to perform their known functions in a conventional process is obvious."

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Applicants respectfully disagree with the Examiner's view. JP 11-106859 does not disclose a quite low level of V. In examples of JP 11-106859, V was admixed at a quite high level, i.e., 19.0 to 40.0 at %. Therefore, JP 11-106859 neither suggests nor teaches the technique for producing hydrogen storage alloys within an extremely low V, Mo and/or W level (i.e., $0 \leq V \text{ at\%} < 10$, $0 \leq \text{Mo at\%} < 5$ and $0 \leq W \text{ at\%} < 5$).

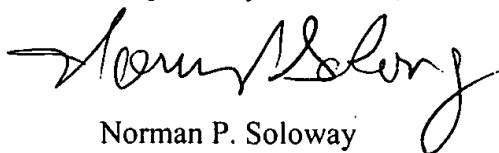
JP 11-106859 completely lacks experimental data in connection with the hydrogen storage alloy containing V at a level of 19.0 at% or less.

Even assuming *arguendo* JP '859 is as the Examiner characterizes it, the more basic and essential combination of features missing from JP '180 are not supplied by JP '859. Thus, no combination of JP '180 and JP '859 could achieve or render obvious claim 22 or claims 29 and 30, which depend thereon.

Having dealt with all the objections raised by the Examiner, the Application is believed to be in order for allowance. Early and favorable action are respectfully requested.

A credit card authorization Form PTO-2038 in the amount of \$860.00 is enclosed in payment of the fee for Petition for Three-Month Extension of Time (\$475.00) and Request for Continued Examination (RCE) (\$385.00). In the event there are any fee deficiencies or additional fees are payable, please charge them (or credit any overpayment) to our Deposit Account No. 08-1391.

Respectfully submitted,



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